MINIMIZING INSECTICIDE REQUIREMENTS IN THE PARAQUAT INDUCTION OF RESINOSIS

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Abstract.--A factorial study was installed in loblolly pine plantations in the Upper Coastal Plain of South Carolina to determine whether selected paraquat treatments with little or no insecticide could produce acceptable lightwood without undue losses from bark beetles. Results indicate that such treatments can be successfully and economically applied within the geographic region of the study and in contiguous areas in Georgia. The most promising treatments without an insecticide spray are 2 or 5 percent paraquat (or 2 percent paraquat with Ethrel) applied to bark streaks made with a power chipper or 2 percent paraquat (with or without Ethrel) applied with a tree injector.

Additional keywords: Bark beetles, lindane, tree mortality, Ethrel, bark streak, tree injector, Pinus taeda.

The efficacy of paraquat, a bipyridyl herbicide, for inducing resinosis in pines has been amply demonstrated, but paraquat treatments have frequently caused serious infestations of bark beetles in the treated trees (Hertel and Williams 1975, Drew 1978). Thus, use of insecticide in preventive sprays immediately after trees are treated, has become virtually standard practice. This insecticide application, however, accounts for 50 percent or more of the total cost of treatment (Stubbs 1978), and it may be neither necessary nor effective, depending on the paraquat treatment used and evidently, geographic area. Results from experiments near Aiken, South Carolina, with 2 or 5 percent paraquat solutions applied to bark streaks with no application of insecticide, indicate that minimal tree mortality is possible for at least 6 to 9 months thereafter (Moore 1978; also see Outcalt and Stubbs in these proceedings).

This evidence and the recent discovery of synergistic action between paraquat and Ethrel[2/] (Peters and others 1978) suggested that, in the geographic area around Aiken, certain paraquat treatments applied with minimal or no insecticide might well induce adequate amounts of resin soaking with minor losses from insects. To test this theory, a factorial experiment incorporating Ethrel and other variables has been installed at the Savannah River Plant near Aiken through interagency agreement with the U. S. Department of Energy. Study objectives are to identify the combination of season, wounding, and chemical treatment that would minimize insecticide requirements while inducing adequate resinosis in loblolly pine (Pinus taeda L.). Interim results from this study are presented here.

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2/ Ethrel is (2-chloroethyl) phosphonic acid. Mention of trade names in this paper is solely to identify materials used and does not constitute endorsement by the U. S. Department of Agriculture.

METHODS

Study installation began in March 1978 in 25-year-old loblolly pine plantations with a site index of 95 (50-year basis). Diameter at breast height (d.b.h.) of each tree was measured; values ranged from 5 to 16 inches.

Experimental Design

The factors involved are the following:

Three blocks or locations,
Three seasonal treatment times (March, June, and November 1978)[3/] within each block,
Two levels of insecticide (0, and 0.25 percent lindane),
Three levels of paraquat (0, 2, and 5 percent),
Two levels of Ethrel (0 and 10 percent),
Two methods of paraquat application (1/3-circumference bark streak or tree injector)

The design is a split-split-plot (in season and insecticide), with a complete factorial of paraquat and Ethrel levels with wounding methods, resulting in 12 factorial treatment combinations. The control (untreated trees) may be considered as an addition to these. Each of the three locations has three plots of 520 trees; each plot was randomly assigned to one of the three seasonal treatment dates. Within each of these 520-tree seasonal plots, the 0.25 percent lindane treatment was randomly assigned to one of two split-plots. The 12 factorial treatment combinations plus the control were applied to subplots of 20 trees within both of the split-plots of a given seasonal replication.

Treatment

Paraquat was applied to individual trees at about 12 inches above the ground. Wounding was done either by a tree injector (Cran-Jector®) on 5-inch centers around the tree, or by a modified chain saw chipper as a 1-inch high, 1/3-circumference bark streak. One ml of paraquat was applied per incision with the injector; with the bark streak, the solution was sprayed on by a calibrated applicator as follows: trees in 6- through 8-inch d.b.h. classes received 3 ml; 9- through 11-inch trees received 6 ml; trees 11 inches and greater received 9 ml. After paraquat was applied, the basal 12 feet of trees in designated split-plots were sprayed with a water emulsion of 0.25 percent lindane.

Data Collection

The cumulative number of attacked and insect-killed trees are being recorded at 1-, 3-, 6-, and 12-month intervals after treatment in each seasonal test. Also at each time interval, two bark samples of about 100 cm^2 each are collected from both of two insect-attacked trees per subplot if available, at a position on the bole which shows evidence of beetle activity. These samples are used to determine whether brood establishment is successful. After 12 months, wood samples from harvested trees will be analysed to determine oleoresin increases.

3/ Results from the November 1978 treatments are not reported, but after 3 months both sprayed and unsprayed split-plots had only 5 percent attack by bark beetles.

RESULTS

March 1978 Test, 6-Month Results

Two species of Ips engraver beetles, primarily I. calligraphus (Germ.), and the black turpentine beetle (Dendroctonus terebrans Oliv.) accounted for all bark beetle attacks; no evidence of the southern pine beetle (D. frontalis Zimm.) was found. Attack by Ips beetles probably caused virtually all of the mortality. The primary differences in the number of trees killed were attributable to paraquat concentration (Table 1). Where no insecticide was used, tree mortality with the 5 percent paraquat concentration was 13.8 percent, whereas with 2 and 0 percent paraquat, mortality was less than 2 percent. Use of insecticide in the 5 percent paraquat treatments reduced average mortality more than 50 percent. Overall mortality with 5 percent paraquat averaged 9.7 percent as opposed to an overall average of only 2.1 percent mortality for 2 percent paraquat.

Incidence of attack, however, was primarily related to whether trees received an insecticide spray. Although degree of attack and degree of subsequent mortality are correlated, they are certainly not synonymous. The overall average for trees attacked by bark beetles was about 6 times higher in the unsprayed than in the sprayed split-plots; nevertheless, the difference in tree mortality was less than 2 percent.

In split-plots where insecticide was applied, there were only minor differences between the injector and chipper (bark streak) wounding methods in the percentage of trees attacked or killed (Table 1). In the split-plots without insecticide, these differences were much more pronounced. As can be seen in Table 2, there appears to be a positive interaction between injector wounding and 5 percent paraquat. With this combination, tree mortality was 18.4 percent when Ethrel was added and 29.0 percent without Ethrel. However, when 5 percent paraquat was applied to a bark streak made by a power chipper, tree mortality dropped to only 6.8 percent when Ethrel was added and to 0 when no Ethrel was added.

Use of Ethrel did not significantly affect either the intensity of attack or tree mortality caused by bark beetles (Tables 1 and 2). If this trend continues, the decision on whether to recommend Ethrel for paraquat treatments of loblolly pine will depend upon oleoresin yield attributable to Ethrel; this determination will be made at the close of the study. Wolter (1977) reported that Ethrel increased extractives yield in red pine (Pinus resinosa Ait.), and the effect was found to be more than additive in slash pine (P. elliottii Engelm. var. elliottii) by Peters and Roberts (1977) and Peters and others (1978). While it is likely that loblolly pine will react in kind, the oleoresin quantity involved is uncertain.

June 1978 Test, 3-Month Results

As in the March 1978 test, Ips spp. and the black turpentine beetle accounted for all bark beetle attacks in the June test. Tree mortality was negligible after 3 months for all paraquat treatments, both in the sprayed and unsprayed split-plots (Table 3). Neither wounding method nor presence or absence of Ethrel had any effect on mortality. The overall percentage of trees attacked, however, was about 15 times higher in the unsprayed than in the sprayed split-plots, regardless of paraquat concentration or wounding method. Use of Ethrel, however, seems to have increased incidence of attack in the unsprayed split-plots (Table 3).

Table 1.--Bark beetle attacks and associated mortality of loblolly pines 6 months after paraquat treatments of March 1978

Treatment Variable	Split-plots With Insecticide		Split-plots Without Insecticide	
	Trees Attacked	Trees Killed	Trees Attacked	Trees Killed
	- Percent -			
Paraquat Concentration				
0 percent	5.0	3.3	7.5	0.7
2 percent	3.3	2.4	42.1	1.8
5 percent	8.8	5.7	50.8	13.8
Wounding Method				
Chipper	4.7	3.4	27.8	1.7
Tree injector	6.7	4.2	39.2	8.9
Ethrel Concentration				
0 percent	3.9	2.8	35.3	5.8
10 percent	7.5	4.7	31.4	5.1
Averages	5.7	3.8	33.3	5.4
Control	0.0	0.0	6.7	2.6

A primary difference between the June and March tests was the incidence of bark beetle attack one month after treatment. Although attack was negligible in sprayed plots, in unsprayed plots attack was about 16 times greater among trees in the June test than among those in the March test (21.3 percent versus 1.3 percent). This difference is probably a function of seasonal activity by the bark beetles; a similar but less extreme difference in seasonal tests was reported by Moore (1978). After 3 months the infestation rates in unsprayed plots were more nearly equal, with 30.1 percent attack among trees in the June test and 19.0 percent among those in the March test. Attack in sprayed plots remained low at about 2 percent in both tests.

Table 2.--Loblolly pines killed by bark beetles in each factorial treatment 6 months after paraquat treatments of March 1978

Treatment Variable	Trees Killed			
	Split-plots With Insecticide		Split-plots Without Insecticide	
	Number	Percent	Number	Percent
0 Percent Paraquat				
Chipper, Ethrel	2	2.7	0	0.0
Chipper, no Ethrel	3	3.8	0	0.0
Injector, Ethrel	5	6.3	1	1.3
Injector, no Ethrel	0	0.0	1	1.4
2 Percent Paraquat				
Chipper, Ethrel	1	1.2	0	0.0
Chipper, no Ethrel	3	4.5	2	3.2
Injector, Ethrel	0	0.0	2	2.8
Injector, no Ethrel	3	4.2	1	1.4
5 Percent Paraquat				
Chipper, Ethrel	6	8.0	5	6.8
Chipper, no Ethrel	0	0.0	0	0.0
Injector, Ethrel	8	10.4	14	18.4
Injector, no Ethrel	3	4.0	20	29.0
Averages	2.8	3.8	3.8	5.4
Control (no paraquat, Ethrel, or wound)	0	0.0	2	2.6

Table 3.--Bark beetle attacks and associated mortality of loblolly pine 3 months after paraquat treatments of June 1978

Treatment Variable	Split-plots With Insecticide		Split-plots Without Insecticide	
	Trees Attacked	Trees Killed	Trees Attacked	Trees Killed
	- Percent -			
Paraquat Concentration				
0 percent	1.3	0.0	8.8	0.3
2 percent	1.7	0.3	40.0	0.7
5 percent	2.9	0.3	41.7	0.3
Wounding Method				
Chipper	2.2	0.2	27.5	0.2
Tree injector	1.7	0.2	32.8	0.7
Ethrel Concentration				
0 percent	1.4	0.0	23.3	0.2
10 percent	2.5	0.4	36.9	0.7
Averages	2.0	0.2	30.1	0.4
Control	5.0	1.1	1.7	1.3

CONCLUSIONS

Although the results presented in this paper are preliminary, some conclusions can already be drawn. It is a virtual certainty that economically viable paraquat treatments can be applied without the need of insecticide sprays. On the basis of 6-month data from the March test, the most promising treatments without an insecticide spray are 2 or 5 percent paraquat (or 2 percent paraquat with Ethrel) applied to bark streaks made with a power chipper, and 2 percent paraquat (with or without Ethrel) applied with a tree injector. When an insecticide spray is applied, all of these treatments, as well as tree injection of 5 percent paraquat without Ethrel, appear favorably.

It must be emphasized that these findings are not applicable throughout the South. To how large a geographic region they do apply is somewhat conjectural, but it is likely that these findings are pertinent to the Upper Coastal Plain of South Carolina and the eastern half of the same province in Georgia, provided that activity by the southern pine beetle is quite low. The need for differing prescriptions, probably by regions, to control bark beetles after paraquat application is evident in the data presented by Drew (1978) and others. For instance, lightwood treatments that can be applied with impunity on the Savannah River Plant may be disastrous in northern Florida. This difference is apparent when the results in this paper and those of Outcalt and Stubbs in this proceedings are compared with the results of Hertel and others (1977) and Merkel (1978).

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